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ral days before, was so cloudy that I attempted in vain to regulate my clock, though I watched every favourable opportunity. On the day of the eclipse I got it pretty well adjusted by several corresponding altitudes of the sun. About 1<sup>h</sup> P. M. the clouds gathered so much round the sun, that I was apprehensive they would prevent any observation. But being pretty much scattered, at 1<sup>h</sup> 36' 42" apparent time, I could very plainly perceive that the eclipse was just begun. This I judged was very near the beginning, if not exactly so, though it was attended with some uncertainty. In a few minutes the sun was wholly covered with the clouds, and remained thus till 3<sup>h</sup>  $\frac{1}{2}$ , when they began again to scatter, and left that part of the heavens in which the sun appeared, perfectly clear. The weather continued thus till the end of the eclipse, which by a good observation was at 3<sup>h</sup> 47' 2". These observations were made with a reflector made by *Nairne*, magnifying as near as I could judge about sixty times; but as to the *quantity* of the eclipse, no observation could be made, the sun being obscured by the clouds the biggest part of the time.

## N° XXXIII.

*An easy and accurate Method of finding a true Meridian Line, and thence the Variation of the Compass.*

By ROBERT PATTERSON.

Read Apr.  
7, 1786.

OF the various methods which astronomers employ for finding a true meridian line, none seems so well adapted, as could be wished, to the common use of surveyors, in finding the variation of the Compass.

To find the azimuth of the sun by a single observation of his altitude, besides a quadrant which is necessary for  
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this purpose, requires the previous knowledge either of the latitude of the place, or hour of the day, at the time of observation; neither of which can, by the common apparatus of a surveyor, be found with sufficient accuracy.

The sun's azimuth may, it is true, be found without knowing either the latitude of the place or hour of the day, by taking equal altitudes before and after noon; but this requires time, attention and instruments, which surveyors can but seldom command.

That method, which is perhaps the most exact, viz. measuring the time between the passage of two stars which differ considerably, in declination and but little in right ascension, over the same vertical circle, is still farther out of the reach of common surveyors.

The following table of the pole star will, it is presumed, furnish a more easy, and yet sufficiently accurate method of determining this problem; free from all the above inconveniencies, and requiring no difficult calculation, nor any other instrument than the common theodolite, or circumferentor. For though the latitude of the place should not be known within a whole degree, nor the hour of the night within 2 or 3 minutes, this table, by a single observation of the magnetic azimuth or bearing of the pole star, will generally give the variation of the needle true to a single minute of a degree. Nay if the observation be made (as it may be every night) when the star is near its greatest elongation, an error of 10, or even 20 minutes in time will, as is plain from the table, produce little or no sensible error in the azimuth. And as these observations may be repeated at pleasure during the night, and a mean of all taken, the variation may, by this means, be found to any degree of accuracy that can be desired. Besides, the needle is not at this time affected with any diurnal variation; which in the day-time is very uncertain, and frequently amounts to more than one quarter of a degree.

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The best instrument for observing the star's magnetic azimuth is a theodolite, furnished with spirit-levels, and a small telescope with a perpendicular wire. A common circumferentor may, however, answer the purpose. When this instrument is used, a fine thread or hair must be stretched along from the top of one sight to that of the other, directly over the center of the compass; and the observer must be very careful to place the sights perpendicular to the horizon when he makes the observation; for this purpose a small pocket spirit-level, in the form of a carpenter's square, would be very convenient.

By the common circumferentor we cannot, indeed, take the bearing of an object with very minute accuracy; for though the eye can very well judge of the coincidence of two lines, or of the point of the needle with any whole degree on the compass, yet the parts of a degree cannot readily be observed to greater exactness than one third or one fourth of the whole. This inconvenience may, however, be easily remedied, and at a very trifling expence, in the following manner.

Let one of the sights, by means of a screw, be made movable at right angles to the index; and on the end of the index, close to the movable sight, set off, on each side of the central line, the tangent of three degrees to a radius equal to the whole length of the index, or distance between the two sights. Let each of these degrees be divided into six equal parts; then will a nonius division on the sight, where ten equal parts must correspond with eleven on the index, subdivide these parts into minutes of a degree.

It will be unnecessary to make the sight move in the arch of a circle, the difference between this and the tangent, in so small an arch, being quite imperceptible. With this simple improvement the common circumferentor will take the bearing of an object true to a minute, thus: Let the end of the needle be made exactly to coincide with the

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nearest whole degree, then move the screw till the object appears in the direction of the sights, and the nonius on the movable sight will point out the odd minutes.

### *Explanation and Use of the TABLE.*

The left hand double column of the table contains the time before the star's passage over the meridian above the pole, for every twenty minutes of its whole diurnal circuit. The first column, under each particular latitude, shews the azimuth of the star at these times, respectively, in degrees, minutes and tenths of a minute. The second column shews the difference of azimuth in every twenty minutes of intermediate time, in minutes and tenths.

To find the true azimuth of the star in any latitude, at any given time.

From the star's right ascension, viz.  $0^h 49^m$ , increased by  $24^h$  if necessary, subtract the right ascension of the sun computed to the time of the star's passage over the meridian, above the pole, nearly, the remainder will be the time of said passage, reckoned from noon. From which, increased by  $24^h$  if necessary, subtract the time of the observation, reckoned also from noon, the remainder will shew the time before the star comes to the said meridian. Look for this time in the left hand column of the table, opposite to which in the column of azimuth, under the proper latitude, you will have the true azimuth of the star at that time.

If the time before the star comes to the meridian be less than 12 hours, its azimuth will be easterly; but if more than 12 hours, its azimuth will be westerly.

If the magnetic azimuth, and the true azimuth at the time of the observation, be both easterly or both westerly, their difference will be the variation of the needle. But if one be easterly and the other westerly, their sum will  
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be the variation. And if the magnetic be to the westward of the true azimuth, the variation will be westerly ; but if to the eastward, the variation will be easterly.

If the time before the star's passage over the meridian be some intermediate minute, or the latitude of the place some intermediate degree, not found in the table, a proportional intermediate azimuth, by means of the differences, must be taken.

The right ascension of the pole star annually increases 10 seconds of time, and its polar distance decreases 20 seconds of a degree, therefore to its present right ascension (in 1785,) viz.  $0^h 49^m$ , must be added one minute every year; and from its present polar distance ( $1^\circ 50'.5$ ) one minute must be subtracted, and a proportional part from all the numbers in the columns of azimuth, every three years. The effect of aberration and nutation may be safely neglected; as the error arising from these causes can never amount to more than half a minute of a degree in azimuth.

In computing the sun's right ascension to the time of the star's passage over the meridian nearly, the following little table will be useful.

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T A B L E.

Time.		Star passes Meridian nearly at
April	2	Noon
	19	11 A. M.
May	5	10
	20	9
June	4	8
	18	7
July	3	6
	17	5
August	2	4
	17	3
September	3	2
	19	1
October	6	Midnight
	22	11 P. M.
November	6	10
	21	9
December	5	8
	19	7
January	1	6
	15	5
	29	4
February	13	3
March	1	2
	17	1

EXAMPLE I.

Suppose on the 12th of September 1785, at 8 o'clock in the evening, in the latitude of  $40^{\circ}$  N. the magnetic azimuth of the pole-star had been observed to be  $0^{\circ} 38'$  easterly; required the variation of the needle at the time and place of observation.

Star's

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	H.	M.
Star's R. A. increased by 24 hours, -	24	49
Sun's R. A. computed to 1 <sup>h</sup> A. M. (taken from the nautical almanac, or any other table of the sun's R. A.) subtract -	11	25
True time of star's passage over meridian, reckoned from noon, - -	13	24
Hour of the night subtract, - -	8	0
Time before star's passage, - -	5	24
Which corresponds to true azimuth, 2° 23' E.		
Magnetic azimuth, - - -	0	38 E.
Variation of the needle, -	1	45 W.

## EXAMPLE II.

In the latitude of about 32° north, on the 4th of July 1785, at 48 minutes after 10 o'clock at night, suppose the magnetic azimuth of the pole star, to be 2° 40' east; required the variation of the needle.

	H.	M.
Star's R. A. + 24 <sup>h</sup> , - - -	24	49
Sun's R. A. - - -	6	54
Time of star's passing meridian, -	17	55
Time of observation, - - -	10	48
Time before star comes to meridian, -	7	7
Which corresponds to true azimuth, 2° 4' E.		
Magnetic azimuth, - - -	2	40 E.
Variation, - - -	0	38 E.

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## EXAMPLE III.

Latitude of the place  $42^{\circ}$  north, time of observation, January 17th 1785, at  $2^h 40^m$  A. M. Magnetic azimuth,  $1^{\circ} 5'$  easterly.

	H.	M.
Star's R. A. + $24^h$ -      -      -	24	49
Sun's R. A.              -      -      -      -	20	1
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Time of star's passing the meridian,      -	4	48
	24	
	<hr/>	
	28	48
Time of observation reckoned from noon,	14	40
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Time before star comes to meridian,      -	14	8
Corresponding to true azimuth, $1^{\circ} 16'$ W.		
Magnetic azimuth,      -      - $1^{\circ} 5'$ E.		
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Variation,      -      -      -	2	21 E.

A TABLE

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Time before the star comes to the meridian above the pole.			Latitude 30°		Latitude 35°		Latitude 40°		Latitude 45°		Latitude 50°		Latitude 55°	
H.	M.		Star's azimuth.	Diff.	Star's azimuth.	Diff.	Star's azimuth.	Diff.	Star's azimuth.	Diff.	Star's azimuth.	Diff.	Star's azimuth.	Diff.
0	24	0	0.0	11.3	0.0	12.0	0.0	12.9	0.0	14.1	0.0	15.6	0.0	17.6
20	23	40	11.3	11.3	12.0	12.0	12.9	12.8	14.1	13.9	15.6	15.4	17.6	17.4
40	20	20	22.6		24.0		25.7		28.0		31.0		35.0	
I	0	0	33.7	11.1	35.7	11.7	38.3	12.6	41.7	13.7	46.2	15.2	52.2	17.2
20	22	40	44.4	10.7	47.2	11.5	50.6	12.3	55.1	13.4	61.0	14.8	68.9	16.7
40	20	20	54.8	10.4	58.2	11.0	62.5	11.9	68.0	12.9	75.3	14.3	84.9	16.0
2	0	0	4.8	10.0	8.8	10.6	13.8	11.3	20.3	12.3	28.9	13.6	40.3	15.4
20	21	40	14.3	9.5	18.8	10.0	24.7	10.9	32.1	11.8	41.8	12.9	54.8	14.5
40	20	20	23.2	8.9	28.2	9.4	34.7	10.0	43.0	10.9	53.8	12.0	68.3	13.5
3	0	0	31.4	8.2	37.0	8.8	44.0	9.3	53.1	10.1	63.9	11.2	80.8	12.5
20	20	40	39.0	7.6	44.8	7.8	52.5	8.5	62.2	9.1	75.0	10.0	93.0	11.2
40	20	20	45.7	6.7	51.9	7.1	60.0	7.5	70.4	8.2	83.0	9.0	102.0	10.0
4	0	0	51.6	5.9	58.2	6.3	67.0	6.7	77.6	7.2	91.7	7.7	110.7	8.7
20	19	40	56.6	5.0	63.4	5.2	72.2	5.5	83.6	6.0	98.7	6.6	120.7	7.3
40	20	20	0.7	4.1	7.7	4.3	16.7	4.5	28.5	4.9	43.7	5.4	64.6	6.6
5	0	0	3.8	3.1	11.0	3.3	20.3	3.6	32.2	3.7	47.7	4.0	68.2	3.6
20	18	40	6.0	2.2	13.3	2.3	22.7	2.4	34.7	2.5	50.3	2.6	71.2	3.0
40	20	20	7.3	1.3	14.7	1.4	24.0	1.3	36.1	1.4	51.7	1.4	72.6	1.4
6	0	0	7.6		14.8		24.2		36.2		51.8		72.5	
20	17	40	6.9	.7	14.2	.6	23.3	.9	35.2	1.0	50.7	1.1	71.0	1.5
40	20	20	5.2	1.7	12.3	1.9	21.3	2.0	33.0	2.2	48.2	2.5	68.1	2.9
7	0	0	2.7	2.5	9.5	2.8	18.3	3.0	29.7	3.3	44.3	3.9	65.3	4.3
20	16	40	59.2	3.5	5.7	3.8	14.2	4.1	25.2	4.5	39.4	4.9	58.2	5.6
40	20	20	54.7	4.5	1.1	4.6	9.2	5.0	19.7	5.5	33.2	6.2	51.2	7.0
8	0	0	49.6	5.1	55.5	5.6	63.2	6.0	73.2	6.5	86.1	7.1	105.2	8.2
20	15	40	43.4	6.2	49.1	6.4	56.3	6.9	67.7	7.5	81.7	8.4	99.7	9.3
40	20	20	36.6	6.8	41.8	7.3	48.7	7.6	57.2	8.5	70.5	9.2	8	